THE PHYSIOLOGY OF POLYPLOIDY IN PLANTS

BY

GLENN RAY NOGGLE

A.B., Miami University, 1935

M.S., University of Illinois, 1942

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN BOTANY IN THE GRADUATE SCHOOL OF THE UNIVERSITY OF ILLINOIS, 1945

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INTRODUCTION

The increasing emphasis of recent studies on the food values of crops makes it important to examine the factors which influence the biochemical activities of plants which are related to the composition of the plant tissues. The influence of increasing the normal number of chromosomes on plant size and on yields of agricultural crops is well known, but the published data have been primarily morphological in nature. It is a matter of considerable interest, therefore, to know how the increase of the number of chromosomes affects the mineral composition, vitamin content, and other nutritive components in plants.

The published literature has indicated that there are physiological differences between diploid and polyploid plants. In general, the polyploids have a slower growth rate, a higher moisture content, and a lower osmotic concentration than the diploid plants. There is no general agreement, however, as to the differences in the chemical composition of diploid and polyploid plants. In order to adequately solve all aspects of this problem, many different plant species would have to be studied since the results found with one species may not necessarily apply to other species. The lack of agreement among authors concerning the differences in composition may be due to their failure to compare the diploids and polyploids at similar stages of development. It is apparent from the published work that the chronological age of the diploid and tetraploid plants is not necessarily equivalent to their physiological age. The composition of plants varies during the period of their physiological development, and this fact must be taken into account when comparisons of diploid and tetraploid plants are made.

The present study was undertaken in order to compare the chemical composition of diploid and tetraploid Rosen rye on the basis of both the chronological and physiological age of the material, and also to determine the relationship between the rate of growth and these chemical changes.

EXPERIMENTAL RESULTS AND DISCUSSION

The purpose of the first experiment was to compare various aspects of the chemical composition of the diploid and tetraploid forms of Rosen rye on the basis of chronological age when the reproductive phase was prevented by the conditions of growth.

Since Rosen rye is a winter variety and requires a low temperature during some part of its vegetative phase in order to complete its reproductive cycle, the conditions of continuous vegetative growth were obtained by growing the plants during the spring of the year.

The second experiment was designed to make possible similar comparisons when the plants were grown under conditions which permitted the reproductive cycle to be completed. Normal reproductive activities were induced by maintaining the germinating seeds at a temperature between 1° and 5° C. for a period of 57 days. The plants were then grown in the spring of the year.

The third experiment was especially designed to compare the two types of plants maintained in the vegetative condition as in the first experiment, but compared on the basis of similar physiological stages of development. The plants were harvested at the time of appearance of the successive leaves regardless of the chronological age. It was found that every seven days a new leaf appeared on both the diploid and tetraploid plants. It was also possible to cut the diploids and tetraploids only a day apart so that a comparison was possible between the two as to growth and compositional changes at approximately equal chronological ages. The time of appearance of the leaves was used as the basis for the comparison of the physiological stages occurring during the growth of the plant.

The fourth experiment was arranged identically to experiment three except that the plants were induced to enter the reproductive stage by vernalizing the germinated seeds at a temperature between 1° and 5° C. for a period of 40 days before planting.

Samples were harvested at intervals and the tissues analyzed. The following data were obtained: green weight, dry weight, tillering, moisture content, and the percentages and total amounts of calcium, magnesium, postassium, iron, phosphorus, nitrogen, ascorbic acid, nicotinic acid, riboflavin, carotene, and chlorophyll.

CONCLUSIONS

1. The tetraploid plants produced fewer tillers than the diploids.

2. The relationships of the condition of tetraploidy to the chemical composition of the tissue may be briefly stated as follows: Green weight was generally greater in the tetraploid plants. Dry weight was always less in the tetraploid plants. Moisture content was generally higher in the tetraploids. Calcium, magnesium, and

nitrogen were less in percentage and in total amounts in the tetraploids. Phosphorus was usually greater in percentage and in amount in the polyploid plants. Iron was generally less in total amount in the tetraploid plants. Chlorophyll and ascorbic acid were lower in concentration on the fresh weight basis in the tetraploids, but were higher on the basis of the dry weight. The total amount of chlorophyll and ascorbic acid was unaffected by polyploidy. Riboflavin was present in smaller concentrations and amounts in vegetative tetraploid plants. Carotene, potassium, and nicotinic acid showed no consistent relationship to the polyploid condition.

.3 The most conspicuous feature of the polyploid plants was their slower rate of physiological development as compared to that of the diploids. Consequently, the polyploid plants are physiologically younger than the diploids at equal chronological ages. Most of the differences in the composition of diploid and tetraploid plants of equal chronological age depend on the fact that the tetraploid plants are physiologically younger.

VITA

The writer was born July 25, 1914, at New Madison, Ohio. He attended elementary school in Sandusky, Ohio, and Dayton, Ohio. He graduated from Steele High School, Dayton, Ohio, in 1932.

He received the Bachelor of Arts degree from Miami University in June, 1935.

He worked as a chemist for the Miami Fertilizer Co., Dayton, Ohio, from 1935 to 1936. From 1936 to 1938, he was a Boy Scout Executive in Steubenville, Ohio. During the school year 1938-1939 he attended Miami University.

In September, 1939, he came to the University of Illinois as an Assistant in Botany. He held a University Fellowship during the school year 1940-1941. During the years 1941 to 1943, he was a half-time Research Assistant in Plant Physiology, supported by a grant from the Cerophyll Laboratories, Inc., Kansas City, Missouri. He received the degree of Master of Science from the University of Illinois in 1942. Since 1943, he has been a full-time Research Assistant in Plant Physiology, supported by a grant from the Cerophyll Laboratories, Inc., Kansas City, Missouri.

He is a member of Sigma Xi and Phi Sigma.

His publications include the following papers:

The effect of soil moisture on the composition of cereal plants. Trans. Ill. Acad. Sci. **33**, 79-80. 1940.

Trace elements in oats and Sudan grass. Trans. Ill. Acad. Sci. **34**, 84-85. 1941.

The determination of selected chemical characteristics of soil which affect the growth and composition of plants. (With F. L. Wynd) Plant Physiology **16**, 39-60. 1941.

The rate of transpiration in two oat varieties. Trans. Ill. Acad. Sci. **35**, 73-74. 1942.

Total nitrogen and vitamin C in oats grown at different levels of soil moisture. Trans. Ill. Acad. Sci. **36**, 103-104. 1943.

Effects of vitamins on germination and growth of orchids. (With F. L. Wynd) Bot. Gazette **104**, 455-459. 1943.

Associations between phosphorus fractions and other chemical components in soil. (With F. L. Wynd) Soil Science **56**, 383-391. 1943.

The following papers are in press:

Applications of spectrophotometric methods to problems of chemical analysis in the study of plant physiology. Trans. Ill. Acad. Sci.

Relationships of certain chemical properties of soils near Midland, Douglas County, Kansas, to yield of oats harvested at the jointing stage. (With F. L. Wynd) Food Research.

Relationships of certain chemical properties of soils near Midland, Douglas County, Kansas, to the accumulation of protein in oat leaves harvested at the jointing stage. (With F. L. Wynd) Food Research.

The influence of chemical characteristics of soil on the production of carotene in leaves of oats. (With F. L. Wynd) Food Research.

The influence of chemical characteristics of soil on the production of vitamin C in leaves of oats. (With F. L. Wynd) Food Research.

Relationships of chemical properties of soils near Midland, Douglas County, Kansas, to yield of rye harvested at the jointing stage. (With F. L. Wynd) Food Research.

Relationships of certain properties of soils near Midland, Douglas County, Kansas, to accumulation of protein in rye leaves harvested at the jointing stage. (With F. L. Wynd) Food Research.

The influence of chemical characteristics of soil on the production of carotene in leaves of rye. (With F. L. Wynd) Food Research.

The influence of chemical properties of soil on the production of vitamin C in leaves of rye. (With F. L. Wynd) Food Research.

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Relationships between fractions of phosphorus in the soil and growth of cereals. (With F. L. Wynd) Food Research.

Relationships between phosphorus fractions in soil and protein accumulation in leaves of cereals. (With F. L. Wynd) Food Research.

Relationships between phosphorus fractions in soil and carotene in leaves of cereals. (With F. L. Wynd) Food Research.

Relationships between phosphorus fractions in the soil and vitamin C (ascorbic acid) production in leaves of cereals. (With F. L. Wynd) Food Research.

Influence of nutritional factors on the correlation between vitamin C concentration and the growth of cereals. (With F. L. Wynd) Food Research.

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